Advanced Laparoscopy: "The Next Generation"

The Adrenal, Kidney, Spleen, Pancreas, and Liver

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Following the rapid acceptance of laparoscopic cholecystectomy, a few adventurous surgeons "dared to boldly go where no one had gone before." They sought to achieve the same reduction in morbidity while accomplishing the same surgical goals. This paper will briefly review the current status of minimal access surgery for the solid organs of the abdomen. It will focus on the indications, risks, limitations, and on the balance between the trauma of access and the trauma of the procedure itself. As new techniques and equipment emerge and experience and data are accumulated, this balance may shift. Some of these procedures are in their infancy while others are rapidly becoming the new "Gold Standard".

Introduction

In March of this year laparoscopic cholecystectomy celebrated its eleventh birthday. Who in 1987 would even have thought of it? Open cholecystectomy was a well-established procedure which any competent surgeon could perform with a minimum of morbidity. Even Mouret, who was aware of the latest laparoscopic techniques, thought little of it.[1] One day, as he finished a gynecological procedure on a patient who also had symptomatic cholelithiasis, he shifted his laparoscope to the subhepatic area and found a fairly free and supple gallbladder. When he decided to perform the operation laparoscopically rather than opening her upper abdomen, he fired the first salvo in a surgical revolution which continues to this day. Mouret was not particularly impressed and did not report the operation. However, other surgeons in France, the US, and elsewhere adopted and polished the technique. As a result, laparoscopic cholecystectomy has become the "Gold Standard" for the treatment of symptomatic cholelithiasis.

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After the success of this initial procedure, creative surgeons have turned their attention to adapting laparoscopic or minimal access techniques to other surgically treatable conditions. The attempts to assess or to remove all or portions of the solid organs of the abdomen have been among the most innovative and challenging of them all. In deciding whether a minimal access technique has merit, we must consider the balance between the trauma of the access and the trauma of the procedure. Laparoscopic cholecystectomy has been so successful because the major trauma of the procedure - the subcostal incision - has been replaced by 3-4 small access ports. For other procedures: appendectomy, inguinal hernia repair, etc. hospital stays are short and differences in access trauma are harder to prove. As a result, the acceptance of these procedures has been more gradual.

This paper will briefly review the current status of minimal access surgery for the solid organs of the abdomen. It will focus on the indications, risks, limitations, and on the balance between the trauma of access and the trauma of the procedure itself. As new techniques and equipment emerge and experience and data are accumulated, this balance may shift. Some of these procedures are in their infancy while others are rapidly becoming the new "Gold Standard".

The Adrenal

Adrenalectomy is a relatively recent addition to the catalogue of laparoscopic or minimal access techniques. In their retroperitoneal location along the medial aspect of each kidney, the adrenal glands are ideally suited to such an approach. Laparoscopy may improve exposure, hemostasis and specimen retrieval while reducing the morbidity of the access considerably. Careful localization and characterization is necessary to assure safe and complete removal of adrenal lesions.

Indications for Laparoscopic Adrenalectomy

Adrenal Cortical Adenomas

Cushing's Syndrome

The most common cause of Cushing's syndrome is the pituitary hypersecretion of adrenocorticotropic hormone (ACTH). This accounts for 60-70% of cases. Primary adrenal tumors which produce excessive glucocorticoids account for 15-20% of patients with the syndrome. The remainder have ectopic ACTH-secreting tumors. Patients with elevated cortisol levels and low plasma ACTH should undergo a CT or MRI to search for a primary adrenal lesion. One of

our patients was a young woman with the typical features of Cushing's syndrome who presented with an acute psychotic break due to the excess production of cortisol. After the laparoscopic removal of a unilateral adenoma, her "psychosis" abated and the Cushingoid stigmata are gradually resolving. Unilateral laparoscopic adrenalectomy is appropriate for discrete masses. Bilateral adrenalectomy is an option for those with bilateral adrenal hyperplasia who have failed to respond to treatment of a primary pituitary cause.

Aldosteronoma

Conn's syndrome is the result of an excess production of aldosterone by cells of the adrenal glomerulosa. Refractory hypertension and spontaneous hypokalemia should prompt the search for a tumor. Sixty-five percent of primary hyperaldosteronism is due to an adenoma. Bilateral adrenal hyperplasia accounts for most of the remaining cases. Once the diagnosis of primary aldosteronism is made the distinction between adenoma and hyperplasia must be made to assure the proper treatment. The most useful tests to make this distinction are CT, MRI, and adrenal venous sampling of aldosterone levels. The small size (1-3cm) of benign aldosterone-producing adenomas make them ideal for laparoscopic removal.

Adrenal Medullary Tumors

Pheochromocytoma

These lesions are catecholamine-secreting tumors that arise within the chromaffin tissue of the sympathetic nervous system. They are very uncommon and account for only 0.1% of patients with diastolic hypertension.[2] They appear far more often on examinations than in the Clinic. Although the majority of these tumors occur within a single adrenal gland, they may be bilateral in 10%, may occur in ectopic sites in 10-15%, and may be malignant in 10%. Consequently, the precise characterization and localization of a suspected pheochromocytoma must precede any attempt to remove it.

The classic patient presents with recurrent paroxysmal hypertension, headaches, palpitations, anxiety, and sweating. Increased urinary catecholamines and their metabolites (VMA and metenephrines) establish the diagnosis. Localization with CT, MRI, or ^{131}I-metaiodolbenzyl-guanidine (^{131}I-MIBG) scanning is essential for preoperative planning. During a MRI, T2 weighted images of pheochromocytomas are very bright while those of adrenal cortical adenomas have a lower signal density.[3] Since ^{131}I-MIBG is taken up by pheochromocytomas, but not by normal adrenal medullary tissue, this scan complements the MRI in excluding extra-adrenal or malignant lesions.[4]

There is at least one family in Hawaii with the genetic mutation associated with the Multiple Endocrine Neoplasia syndrome (MEN II_b). Family members with this mutation are being screened for pheochromocytoma prior to undergoing a prophylactic thyroidectomy to avoid developing a medullary carcinoma. We have recently performed bilateral laparoscopic adrenalectomies for one member of this family who was found to have 8cm pheochromocytomas. She did well and is now recovering from her radical thyroidectomy for her medullary carcinoma.

Other Adrenal Tumors

Masses discovered incidentally on CT scan should be evaluated for the excess production of cortisol, aldosterone, and catecholamines. If these tests are negative and the lesions are <3 cm, they may be followed with serial CT scans. Because of the higher risk of carcinoma, lesions >6 cm should be removed irrespective of their functional status. The availability of laparoscopic adrenalectomy may make this the preferred treatment for incidentally discovered tumors which are 3-6 cm in size.

Laparoscopic Adrenalectomy

The first laparoscopic adrenalectomies were performed through an anterior transabdominal approach.[5] This proved to be tedious and the exposure is significantly improved by placing the patient in a lateral decubitus position.[6] In this position, gravity increases the exposure as the viscera fall away from the operative field. Posterior and retroperitoneal laparoscopic approaches have their advocates.[6-8] It is clear that the procedure should be tailored to the number, size, and location of the tumor(s) as well as to the surgeon's preference and experience.

Results of laparoscopic adrenalectomy

The early learning curve associated with any new procedure will result in longer operative times and higher costs. With experience, laparoscopic adrenalectomy can be performed with operative times comparable to more traditional methods. Hospital stay, narcotic requirements, and recovery are all improved when minimal access techniques are used.[8,9] Further follow-up will be required to be sure that the recurrence rate and the incidence of missed lesions, both ectopic and bilateral, is equivalent to open methods. Improved imaging techniques should make this a very rare occurrence.

Prinz RA[7] reported an early comparison of laparoscopic adrenalectomy to two open approaches. His results are summarized in Table 1.

Michel Gagner, who was one of the first to perform a laparoscopic adrenalectomy, recently reviewed his first 100 cases from the Cleveland Clinic.[8] These results are shown in Table 2. Table 3 Summarizes our experience with open and laparoscopic adrenalectomy.

Conclusions

Laparoscopic adrenalectomy is a relatively new procedure. Its safety and efficacy in experienced hands has been clearly demonstrated in a growing number of reports. By reducing the trauma of access, it has definite advantages over the traditional open methods. However, open adrenalectomy is still the preferred method for patients with adrenal cortical malignancies.

The Kidney

The first successful human nephrectomy was performed in 1869 by Gustav Simon.[9] Although it has become a standard operation for urologists, the large incision required is associated with significant pain, prolonged recovery, and the risks of infection and herniation. The successful application of minimal access techniques to nephrectomy would reduce the trauma of access and hasten recovery. After working out their technique in the animal lab, Drs Clayman and Kavoussi performed the first laparoscopic nephrectomy in June of 1990.[10]

Indications for Laparoscopic Nephrectomy

Benign renal diseases requiring nephrectomy are suitable to the laparoscopic approach. These include end-stage reflux nephropa-

Table 1.— Comparison of Open and Laparoscopic Adrenalectomy. Prinz, 1995[7]

		Open	
	Laparoscopic (n = 10)	Posterior (n = 13)	Anterior (n = 11)
Operating Time (min)	212	139	174
Blood Loss (ml)	228	288	391
Length of Stay (days)	2.1	5.5	6.4
Parenteral Analgesia (doses)	1.4	14.5	15.8

Table 2.—One hundred laparoscopic adrenalectomies at the Cleveland Clinic. Gagner, 1997[8]

Operating Time (min)	123 (80 - 360)
Size (cm)	4.95 (0.7 - 12)
Blood Loss (ml)	70 (<20 - 1300)
Conversion to open	3%
Complications	12%
Length of Stay (days)	2.4 (1 - 19)
Parenteral Analgesia (doses)	5.5

Table 3.— Recent experience with laparoscopic and open adrenalectomy at Kaiser, Hawaii

	Open (n = 6)	Laparoscopic (n = 9)
Mean Operating Time (min)	170	165
Blood Loss (ml)	225	<50
Size (cm)	1 - 10	1.5 - 4
Length of Stay (days)	5.8	2
Parenteral Analgesia (doses)	16	6
Return to Work (days)	25	7

Table 4.— Laparoscopic nephrectomy for benign and malignant renal lesions. Clayman, 1993[14]

Number		32
Age (yrs)		16 - 91
Indications		
	Benign	28
	Malignant	4
Operating Time (min)		
	Benign	340
	Malignant	437
Blood Loss (ml)		211
Length of Stay (days)		3.7
Complications		37%

thy; renal vascular hypertension; poorly functioning kidney due to chronic obstruction; recurrent pyelonephritis; and, with extensive experience, living-related donor nephrectomy. Laparoscopic total or radical nephrectomy has also been reported for small (< 5cm) renal tumors.

Operative Approaches

Both the lateral, transabdominal[11] and the retroperitoneal[12] approaches have been described. The latter is facilitated by the use of dissection balloons first described by Gaur.[13] These balloons are now commercially available and are similar to the ones used for laparoscopic inguinal hernia repair. This is particularly valuable for patients who have had prior abdominal operations. The choice of approach will also be governed by the surgeon's experience and preferences.

Results of Laparoscopic Nephrectomy

Clayman, et al have one of the largest series of laparoscopic nephrectomies. A recent report[14] of their initial experience is presented in Table 4. Table 5 summarizes several authors' results with laparoscopic retroperitoneal nephrectomy.

Two patients have undergone laparoscopic nephrectomy for benign disease at the Kaiser Foundation Hospital in Honolulu. Learning from these early pioneers and from our own experience in other complex laparoscopic procedures, we have had very similar results.

Laparoscopic Donor Nephrectomy

Donor nephrectomy is a unique operation. It confers absolutely no benefit to the patient and damage to the removed kidney harms two patients. Open donor nephrectomy is not without risk. Clayman cites several series where the complication rate was similar to those reported in his series listed above. However, Flowers[15] (Table 6) has reported excellent results in a case-controlled series which is now >150 patient donors. He has proposed that if the procedure were more available, more relatives might chose to become donors.

Conclusion

For properly selected patients, laparoscopic nephrectomy offers the benefits of minimal access surgery while accomplishing the same surgical goals. Those considering this approach should collaborate with experienced laparoscopic colleagues to shorten the "learning curve". Whether laparoscopic donor nephrectomy will find broader acceptance and increase the donor pool will require careful monitoring of results from the pioneer centers.

The Spleen

The first successful splenectomy was performed during an exploratory operation for a suspected ovarian tumor. The surgeon, Jules Pean (1830 - 1898), was a well respected pioneer in French surgery. He was, perhaps, the first of the French surgeons whose efforts were pivotal in the development of minimal access surgery. His skill in removing a very large splenic cyst and the remaining spleen is evident in his report.[16] The operation took two hours and "less than 100 gms of blood were lost". This was well before the availability of electrosurgical, argon beam, ultrasonic, or surgical stapling devices. The patient seemed to have had more trouble from the chloroform-induced vomiting than from the operation!

Indications for Laparoscopic Splenectomy

Splenectomy is often indicated for hematological diseases which result in the damage or destruction of the formed elements of the blood or for staging hematological malignancies. These include immune[17,18] and idiopathic[19] thrombocytopenic purpura, hemolytic anemia,[20] or Hodgkin's lymphoma.[21] Early in one's experience, small spleens in patients without significant co-morbidities are the most appropriate. However, more experienced laparoscopists are reporting the removal of very large specimens - in excess of 300 grams. Preoperative angiographic embolization of the splenic artery may be helpful with these large spleens or early in a surgeon's experience. It is not usually necessary with the smaller ones and may cause pancreatitis, especially if gel foam is used for the embolization.[19] We have not used preoperative embolization for our laparoscopic splenectomies.

Searching for accessory spleens is an important step in the procedure. Advanced laparoscopic skills and repositioning the patient frequently to improve exposure are essential. Although there is not general agreement on whether preoperative scanning is necessary to identify accessory splenic tissue, it may be valuable in obese patients or early on the a surgeon's "learning curve".

Most resected spleens are placed into a sturdy sac and morcellized for removal. While this has raised questions about the suitability of the specimen for pathological examination, the large pieces are adequate in most cases.

Results of Laparoscopic Splenectomy

Until randomized, prospective trials are available, case-controlled studies are helpful in evaluating the procedure. One such trial was recently published by Diaz.[22] (Table 7)

Conclusions

As with the previously described procedures for adrenalectomy and nephrectomy, laparoscopic splenectomy may permit us to reduce the trauma of access while accomplishing the same surgical goals. This is another "ideal operation" for laparoscopy and is well on the way to establishing itself as the "gold standard" for the procedure.[18]

The Pancreas

Pancreatic resections are usually performed for cancer, for the intractable pain of chronic pancreatitis or for the drainage or resection of pseudocysts.[23] For peripancreatic cancer, pancreaticoduodenectomy with adequate node clearance has shown steadily improving results. With thorough staging,[24] patients can be more accurately chosen for exploration and attempted resection. Laparoscopic surgery of the pancreas is still in its early stages of development. Although the entire gland can be visualized laparoscopically, it cannot be thoroughly palpated. Laparoscopic ultrasound may allow us to overcome this obstacle.

Laparoscopic pancreaticoduodenectomy has been successfully accomplished by a few exceptionally skilled surgeons.[25,26] However, even they feel that the procedure is of little real benefit to the patient. Currently, laparoscopic pancreatic surgery is best suited for the localization and enucleation of benign islet cell tumors and distal resections for chronic pancreatitis. Staging malignant tumors laparoscopically and bypassing those which are unresectable are also becoming more widely done.

Table 5.— Laparoscopic retroperitoneal nephrectomy in several centers. Perle, 1996[12]

#	Success (%)	OR Time (hrs)	EBL (ml)	LOS (d)	Comps (%)
154	63-100	1.9 - 5.1	<150	<3-8	0 - 15

Table 6.—A comparison of open & laparoscopic live donor nephrectomy. Flowers, 1997[15]

	Open	Lap	p=<
Number	65	69	
Operating Time (min)	212.8	226.3	0.1658
Conversion to Open	-	6%	
Blood Loss (ml)	408	122.3	0.0001
Length of Stay (days)	4.5	2.2	0.0001
Graft Survival (%) [mean FU: 7 months]	64 (98)	67 (97)	0.6191
Delayed Graft Function (%)	1 (2)	2 (3)	0.4961
Parenteral Analgesia (doses)	60.1	28.6	0.0001
Recovery (d)			
Housework	26.9	8.8	0.0001
Driving	31.6	11.1	0.0001
Working	51.5	15.9	0.0001

Table 7.— Case-controlled study of open and laparoscopic splenectomy. Diaz, 1997[22]

	Open	Lap	p=<
Number	15	15	
Splenic	492	305	N.S.
Weight (g)	(64 - 1130)	(63 - 878)	
Operating Time (min)	116 ± 64	196 ± 71	0.0031
Conversion to Open	-	0	
Blood Loss (ml)	359 ± 318	385 ± 168	N.S.
Length of Stay (days)	8.8	2.3	0.001
Return to Full Activity (days)	23 (14 - 46)	12 (5 - 22)	0.01
Cost ($)			
OR	4372	12827	0.0001
Hospital	6553	1389	0.0005
Total Cost	10925 ± 8752* *2 readmissions	14216 ± 2550** ** No readmissions	N.S.

The Liver

The size and complexity of the liver make it a formidable surgical challenge. It remains the last of the abdominal organs to be approached laparoscopically. From the method of exposure to the removal of the specimen, evolving technology will be required to make laparoscopic hepatic surgery safer and more effective.

Indications for Laparoscopic Hepatic Surgery

Diagnostic laparoscopy with intraoperative ultrasound can detect primary and metastatic lesions which may have eluded prior studies. The management of hepatic cysts has been changed by the advent of laparoscopy. Unroofing and fenestration can lead to the resolution of such cysts.[27,28] The reduced trauma of access can allow a much more rapid recovery and occasionally spare the patient an unnecessary celiotomy.[24]

The Future of Laparoscopic Hepatic Surgery

A small lesion metastatic to the left lobe may be considered for laparoscopic resection. Using blunt and ultrasonic dissection such a lesion can be resected with an adequate (2cm) margin of normal tissue. When a major hepatic vein is encountered, switching to mechanical lifters and a "gasless" laparoscopic environment may help to prevent a CO_2 embolism. Adventuresome surgeons in Europe have attempted larger resections on both sides of the falciform ligament.[29] However, better instruments for dissection and hemostasis as well as the FDA's approval of fibrin glue will be necessary if such procedures are to become more commonly performed in the US.

Comment

Laparoscopic surgery has grown considerably from the early "observation" and simple diagnostic efforts of physicians seeking to avoid a surgical procedure for their patients. Surgeons skilled in the techniques of minimal access surgery are now able to approach nearly every organ of the body. While some of these procedures remain developmental and controversial, others have become the new "Gold Standard". Since many of the problems reviewed are relatively rare and the techniques can be difficult to learn, it may be appropriate to concentrate the experience in a few very experienced laparoscopists. This has been the approach at UCSF, Kaiser in Hawaii, and at other institutions. The challenge for surgeons as we wage an unwinable battle against obsolescence is to carefully evaluate each new innovation and be certain that fundamental surgical principles are honored and treatment goals are realistic. As Lord Moran, Churchill's personal physician, observed:

"The feasibility of an operation is not the best indication for its performance."

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